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COTTON SEED-TREATMENT STUDIES AT THE BLACKLAND EXPERIMENT STATION

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Figure 1. Plants from acid-delinted seed, left, and Ceresan-treated seed, right, were approximately twice as large as plants from nontreated seed, center, planted at the same time. Seed treatment prohibits to a large measure early stunting of plants by disease-producing organisms. Plants from treated seed can also be cultivated earlier.

Experiments over a period of six years have shown increased emergence, decreased seedling infection, and improved yields by treating cotton seed with fungicides, or delinting, or a combination of both. Fungicidal materials were found more effective on fuzzy seed than on delinted seed. Delinting alone compared favorably with other treatments; however, in some experiments the results from delinting were improved by the addition of a protective fungicide.

No one fungicide was consistently superior to another, nor was the amount used differentially effective. In addition to the commonly-used mercurial compounds, certain copper materials, a Cyanamid mercurial compound, an iodine mixture and a nonmetallic fungicide gave good results.

Southeastern-grown seed developed much less angular leaf spot in the seedling stage than Texas-grown seed. Fractionation of seed by differences in weight or specific gravity had little or no effect in field performance.

Seed treatment was most important for obtaining good stands of plants where low rates of seeding were used. Conversely smaller quantities of seed would be required when treated seed is used. The cost of the treatment is only five to ten cents per bushel of seed and any yield increase obtained would justify the slight expense.

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COTTON SEED-TREATMENT STUDIES AT THE BLACKLAND EXPERIMENT STATION[1]

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Treatment of cotton seed with fungicidal materials has two main purposes: (a) disinfection of the exterior parts of the seed against any disease germs that may be carried on the seed, and (b) protection of the seed and young seedlings against attack by fungi in the soil. Obviously, the need for seed treatment and the benefits derived therefrom depend much upon the condition of the seed and upon the soil and weather conditions immediately following planting. Seed from a field badly infested with angular leaf spot, for example, would require treatment to reduce losses from this disease in a new field. Also, seed planted early in the season, when the soil is likely to be wet and cold, would produce a better stand if the seed were treated. Although the beneficial effects of cotton seed treatment are partially obscured by the usual practice of thick planting and removal of many weak or diseased plants at chopping time, our experiments in the Texas Blacklands have shown that profitable increases in yield of cotton can usually be obtained by treating the seed regardless of the method and time of planting.

Diseases Controlled by Seed Treatment

Under Texas conditions, the two most important seedling diseases are angular leaf spot *(Bacterium malvacearum)* and sore shin (usually associated with *Rhizoctonia solani* although other organisms may be present). Sore shin is detected by brown, diseased areas on the stem either above or below the ground line. Seedlings affected with sore shin are shown in Figure 2. The young plants may recover from sore shin but they are often delayed in development.

Angular leaf spot usually appears first on the cotyledons (seed leaves) as small, green, water-soaked spots which look somewhat like bruises. The spots later may occur over the entire affected part of the plant. If the weather is damp following emergence of seedlings, this disease may kill many of the plants, especially where infection is severe as is often the case with nontreated seed. Angular leaf spot is next to Phymatotrichum root rot in severity of damage to cotton in the Blackland area. In some years the losses are estimated to exceed those caused by root rot. An example of angular leaf spot infection on young plants is shown

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[1]These investigations were aided by the Work Projects Administration, Federal Works Agency, under projects operating almost continuously from 1936 through February 1942. Certain experiments were conducted in cooperation with the Cotton Seedling Disease Committee of the American Phytopathological Society.

[2]Dr. Rogers resigned June 1, 1942 to accept a position with the Coker Pedigreed Seed Company, Hartsville, S. C. His successor, Dr. E. W. Lyle, completed the 1942 data and was assigned the duty of completing the manuscript for publication.

Figure. 2. Cotton seedlings affected with sore shin.

Figure. 3 Angular leaf spot which has spread from the cotyledons or seed leaves to the stem, causing a blighted condition and falling over of the top.

in Figure 3, where the young cotyledons were destroyed and the disease spread to the stem, killing and shriveling the tissues so that the entire top of the plant later collapsed. This disease also destroys young buds in the early stages of development of the plant and reduces the yield considerably by preventing formation of the first fruiting branches that ordinarily would bear an early crop of bolls. Such a condition is shown in Figure 4. Angular leaf spot infections on leaves of a full grown plant are shown in Figure 5 and on cotton bolls in Figure 6.

Proper treatment of cotton seed insures a more vigorous plant during the early stages of development, which permits earlier and more thorough cultivation. The relative stand and size of plants from untreated seed, from acid delinted seed, and from seed treated with 5% (New Improved) Ceresan are shown in Figure 1. In these experiments, seedlings from treated seed were often about twice as large during the early stages of growth as seedlings from seed not treated.

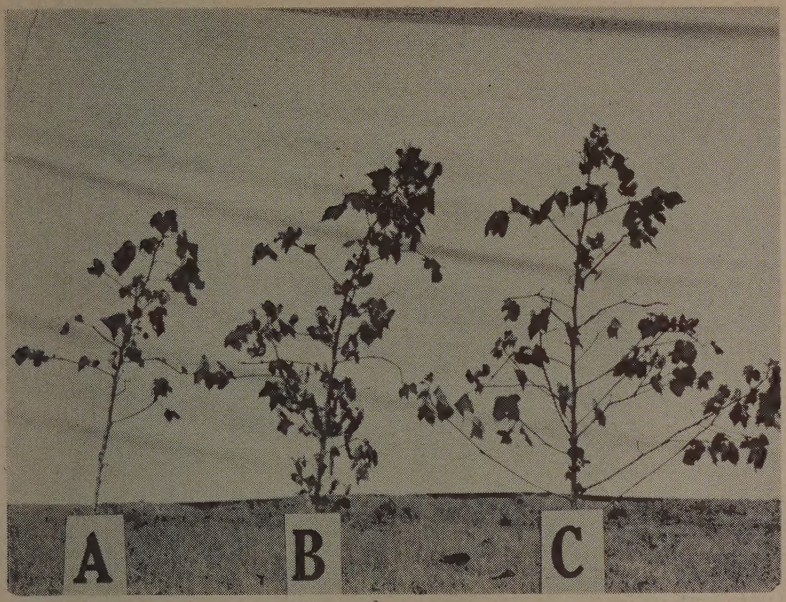

Figure 4. A. Angular leaf spot prevented development of early branches on the cotton plant at the left by killing the buds. B. Initial buds were killed, but small branches developed late in the season from dormant buds. Plants A and B were grown from nontreated seed. C. A plant from treated seed that had three early-formed fruiting branches with four good sized bolls.

Figure 5. Angular leaf spot on cotton leaves. The disease is first evident and is more readily detected on the under side of the leaves.

During the last twenty years many materials for treating cotton seed have been tested with the purpose of preventing loss from seedling diseases and improving the stand of plants. Some of the earlier work consisted of treating seed with materials of a nonfungicidal nature such as fertilizers or similar materials. Hall and Armstrong (5)[3] found that germination was delayed by rolling cotton seed in nitrate of soda. More recently, the use of fungicidal dusts has been shown to increase stands of cotton, and in most cases to give yield increases. Woodroof (15) recommended the use of four ounces per bushel of 2 percent Ceresan and found that a number of such dusts applied to cotton seed resulted in improved stands and increased yield. Delinting cotton seed with sulphuric acid has been tested at various locations, and in most instances this treatment has been found to improve the stand of seedlings, decrease the amount of seedling disease, and to make for larger yields. Faulwetter (4) in South Carolina in 1919 reported control of angular leaf spot by use of mercuric chloride on seed previously delinted with sulphuric acid. Brown (2) recommended acid delinting for blackarm control in Arizona. Arndt (1) reported that germination of acid-delinted seed was 40 percent higher than fuzzy seed, and that acid-delinted seed plus Ceresan gave a 54 percent increase in germination over untreated seed. Practically all workers over the entire cotton belt (1, 3, 6, 7, 8, 9, 10, 11, 13, 14, 15, 16) report that the mercurial dusts have in general been superior to other compounds as a chemical treatment for cotton seed. Acid delinting has generally been recommended for the drier sections (Texas, Oklahoma, and other parts of the Southwest), although the treatment with mercury-containing dust also gives results in these regions similar to those in the southeastern states.

Methods

The experiments reported in this bulletin were conducted on Austin clay and Houston black clay soil at the Blackland Experiment Station, Temple, Texas. The plots varied in size from year to year; those in 1932 and 1938 were three rows wide and 132 feet long. In the other years they were single row plots either 66 or 132 feet long. All rows were spaced 36 inches apart. The land was prepared in the ordinary manner, usually by flat breaking in late fall and bedding in late winter. The general practice of applying no fertilizer was followed. In all experiments, the seed were planted by hand in hills 18 inches apart, the treatments were replicated from four to six times and the locations of the plots were randomized. Treatment with fungicidal chemical dusts was done either with a rotary seed treater or by shaking the seed and fungicide together in a container of convenient size—such as a fifty- or one hundred-pound lard can, each treatment interval being of the same length for all seed lots in any given experiment. The quantity of dust used per bushel of seed varied with the experiment, but in most

[3]Numbers in parentheses refer to literature cited.

cases the same relative amount of active ingredients were applied per bushel. Acid delinting was done at the Experiment Station using concentrated commercial sulphuric acid, at the rate of about 2 quarts per bushel of seed. The seed were stirred with the acid until the lint was dissolved; then they were washed in running water and immediately dried. Commercial acid delinting was done by the Kemgas method (fumes from a mixture of sulphuric and hydrochloric acids) and the Brown-Streets method (sulphuric acid water-flotation process). Seed were machine delinted by reginning in a small portable gin at the Station or at a local oil mill. Chemical dusts tested during the course of this work included 2% Ceresan (2 percent ethyl mercury chloride), Sanoseed (2 percent ethanol mercury chloride), New Improved (5%) Ceresan (5 percent ethyl mercury phosphate), Cyanamid 154-6-B (5 percent beta chloroethoxy mercury acetate), Du Bay 1155 JH, Du Bay 1155 HH, Du Bay 1155 IW, and Du Buy 740 A (all similar to the 5 per cent Ceresan in concentration of active ingredient). Nonmercurial compounds included: Spergon and Spergonex (99 percent and 50 percent tetrachloroparabenzoquinone, respectively), Red Cuprocide (96.5 percent metallic copper), Yellow Cuprocide (93 percent copper), copper sulphate (blue vitriol), and copper carbonate (56 percent copper). Results with other materials tested for only one year are not given in the tables;

Figure 6. Angular leaf spot (bacterial boll rot) on cotton bolls. Infected bolls may open, but a low yield of poor quality lint is obtained.

in some cases the manufacturers advised they could not be produced commercially.

In order to obtain information as to the effect of treatment on earliness of emergence, the seedlings that had come up were counted in some years approximately ten days after planting. The usual final emergence counts, however, were made thirty days after planting or as near this time as the weather would allow. At this time, data were also taken on the number of seedlings infected with angular leaf spot. Loss of seedlings due to the sore-shin disease and to pre-emergence damping-off was reflected in the final counts and no attempt was made to count the seedlings that were affected but not killed by sore shin. During the past several years, angular leaf spot has been the most important seedling disease in the Blackland area of Texas.

All plants in each replication were counted to obtain emergence records. The term "percentage emergence" represents the ratio of number of plants emerged to the number of seed planted. The infection data show the percentage of infected or diseased plants based upon the total number of plants examined, consisting of the plants in ten hills at two different locations within each replication. Yields per acre are based on the yield from all replications in a given treatment.

Comparison of Different Treatments

Effects on emergence. The effects of a number of different treatments on emergence and early stand of cotton seedlings are shown in the first part of Table 1. In this experiment, the seed were planted on two different dates, each year, approximately the first of April and the first of May. In 1941 and 1942 (see Table 2), seed were planted on only one date (April 1, 1941 and April 13, 1942) but two varieties were used each year. This included Texas-grown and southeastern-grown seed, the latter received through the cooperation of the Cotton Disease Council of the American Phytopathological Society. Texas-grown Rogers' Acala 111 seed were planted in each of these two years, while southeastern-grown Deltapine 12 (D. & P. L.) and Stoneville 2B seed were planted in 1941 and 1942, respectively. In all of these experiments, the seed treatment increased the percentage emergence except in a very few cases, regardless of the materials used. Of the better materials one was not consistently superior to another. In some tests, acid delinting plus the organic mercury compound, Ceresan, appeared best. In others Cuprocide (copper oxide), an inorganic mercury compound (calomel), Cyanamid 154-6-B, and even an iodine material appeared to improve emergence effectively. In certain experiments Spergon, a nonmetallic fungicide, was advantageous. Over several years, the delinting treatment with sulphuric acid alone was very good—and compared favorably with the dust treatments. The addition of indolebutyric acid (IBA) to the 5 percent Ceresan (Table 6) showed little benefit beyond that obtained with 5 percent Ceresan alone. No increase

Table 1. Effects of seed treatment at two planting dates on emergence, angular leaf spot infection, and yield of cotton.[1]

Treatment	Rate, oz. per bu.	1932		1938		1939		1940		Average difference from checks for same years	
		E[2]	L[3]	E	L	E	L	E	L	E	L
Seedling emergence—percent of seeds planted											
No treatment (check)	0	42.1	48.3	37.3	31.4	33.4	40.1	56.2	57.6	--	--
2% Ceresan	3	70.8	75.3	66.6	64.5	69.7	67.5	73.7	75.3	28.0	26.2
5% Ceresan	1½	--	--	70.7	--	71.8	79.3	67.9	78.2	27.5	30.0
Sanoseed	3	--	--	--	--	49.5	55.9	56.2	57.2	8.0	7.8
Acid delinted	0	61.8	71.7	42.0	48.7	66.8	66.8	64.2	77.7	16.5	21.8
Acid del. + 2% Ceresan	3	--	--	-	--	74.0	78.0	64.8	81.1	24.6	30.8
Acid del. + 5% Ceresan	1½	--	--	--	--	76.7	75.9	72.3	79.6	29.7	29.0
Acid del. + Sanoseed	3	--	--	--	--	62.8	70.5	63.8	76.7	18.5	24.8
Percentage of seedlings with angular leaf spot											
No treatment (check)	0	38.9	1.0	39.3	57.9	52.6	72.8	31.9	20.0	--	--
2% Ceresan	3	3.9	0.7	13.6	16.9	4.0	19.3	2.5	6.7	-34.7	-27.0
5% Ceresan	1½	--	--	14.9	--	4.4	14.0	3.4	5.4	-33.7	-36.7
Sanoseed	3	--	--	--	--	3.2	21.7	7.7	3.8	-36.8	-33.6
Acid delinted	0	3.8	0.7	14.6	33.0	1.7	28.5	8.7	2.4	-33.5	-22.3
Acid del. + 2% Ceresan	3	--	--	--	--	1.5	18.8	9.1	3.4	-36.9	-37.8
Acid del. + 5% Ceresan	1½	--	--	--	--	2.1	10.2	6.9	2.4	-37.7	-40.1
Acid del. + Sanoseed	3	--	--	--	--	3.2	21.7	7.7	3.8	-36.8	-33.6
Yield of seed cotton—pounds per acre											
No treatment (check)	0	425	420	739	711	605	616	522	475	--	--
2% Ceresan	3	584	431	907	759	748	715	675	536	130.7	54.7
5% Ceresan	1½	--	--	874	--	759	748	605	407	124.0	32.0
Sanoseed	3	--	--	--	--	759	847	524	504	78.0	130.0
Acid delinted	0	666	570	768	770	759	825	641	560	135.7	125.7
Acid del. + 2% Ceresan	3	--	--	--	--	759	825	695	524	163.5	129.0
Acid del. + 5% Ceresan	1½	--	--	--	--	715	737	630	544	109.0	95.0
Acid del. + Sanoseed	3	--	--	--	--	836	781	578	472	143.5	81.0

[1]Qualla variety was planted in 1932 and Rogers' Acala 111 in the other years.
[2]Early planting, about April 1.
[3]Late planting, about May 1.

in the growth of seedlings or plants was observed with the addition of this growth-promoting substance to the Ceresan dust, or when used in aqueous solutions for soaking the seed before planting.

Seedling infection. As shown in the second part of Table 1, some control of angular leaf spot was always obtained regardless of the treatment involved. Acid delinting alone reduced angular leaf spot infection on seedlings to a marked degree, as compared to infection on seedlings from untreated seed. All the chemicals tried except Spergonex gave marked reduction in seedling infection. Rains following emergence were noted apparently to increase the amount of infection by the angular leaf spot organism. In Table 2, it will be noted that there was little or no angular leaf spot on the Deltapine seedlings. Very few lots of seedlings from southeastern-grown seed planted at the Temple substation have shown much infection by the angular leaf spot organism, indicating a low incidence of infection in these regions for the respective years.

Yield. Inasmuch as 10 seed per hill were planted in most of these tests and the stand was thinned to 2 plants after emergence and infection counts were obtained, the yields were not in proportion to the effects of treatment on emergence and seedling disease. In keeping with farm practices, the best plants were left at thinning regardless of the treatment. On this account, another experiment (given later in this bulletin) was made to obtain a more direct comparison of treatment to yield by varying the rates of planting. Also, the cotton root-rot disease was another factor that contributed to wide fluctuation in yield from year to year. Usually, the plants that developed earliest were the first to be infected or killed by cotton root rot. However, differences in infection by the cotton root-rot disease were not consistent from year to year for any given treatment.

As shown in the last part of Table 1, all seed treatments gave some increase in seed-cotton yield. Over the period of years represented in this table, seed delinted with sulphuric acid alone produced 125 pounds more seed cotton per acre than untreated seed. However, in 1941, one of the wettest seasons on record, acid delinting did not result in increased yields (see Table 2) as in previous years. During the 1941 season, seed that were delinted with sulphuric acid and then dusted with

Table 2. Effects of various seed treatments on Texas-grown seed (Rogers' Acala 111) as compared with southeastern-grown seed (Deltapine 12 and Stoneville 2B).

Treatment	Rate, oz. per bu.	Texas-grown Rogers' Acala 111			Southeastern-grown		
		1941	1942	Ave.	Deltapine 12	Stoneville 2B	Ave.
					1941	1942	
Seedling emergence—percent of seeds planted							
No treatment	0	52.3	47.0	49.6	55.0	49.0	52.0
5% Ceresan	1½	62.7	69.0	65.8	62.8	76.0	69.4
Acid delinted	0	52.5	62.5	57.5	56.5	73.6	65.0
Acid del. + 5% Ceresan	1½	55.4	70.3	62.8	64.2	74.6	69.4
Spergon	1½	63.2	71.0	67.1	60.4	71.2	65.8
Spergonex	3	58.9	74.0	66.4	58.9	68.6	63.8
Cyanamid 154—6-B	1½	61.0	66.0	63.5	54.4	72.2	63.3
Seedling infection—percentage of seedlings with angular leaf spot							
No treatment	0	89.3	92.3	90.8	0.4	3.7	2.0
5% Ceresan	1½	3.1	8.0	5.6	1.5	0.0	0.8
Acid delinted	0	0.0	0.0	0.0	1.3	0.6	1.0
Acid del. + 5% Ceresan	1½	1.0	0.0	0.5	0.9	0.0	0.4
Spergon	1½	4.8	3.7	4.2	1.3	2.8	2.0
Spergonex	3	50.8	64.4	57.6	1.2	2.7	2.0
Cyanamid 154—6-B	1½	1.9	9.6	5.8	1.0	6.8	3.9
Yield of seed cotton—pounds per acre							
No treatment	0	748	405	576	581	651	616
5% Ceresan	1½	645	625	635	587	814	700
Acid delinted	0	691	---	---	609	---	---
Acid del. + 5% Ceresan	1½	1008	---	---	887	---	---
Spergon	1½	845	519	682	757	739	748
Spergonex	3	717	528	622	550	713	632
Cyanamid 154—6-B	1½	702	682	692	845	770	808

5 percent Ceresan gave yields that were much higher than those obtained with delinting or dusting alone. In most years early plantings outyielded late plantings. This was true in about three-fourths of the trials.

Effects of Various Seed Treatments on Two Eastern-Grown Varieties of Cotton Seed (Supplemental test—1940)

In the 1940 experiments, seed of Stoneville 2B and Deltapine 12 were treated with different materials at the South Carolina Experiment Station and planted at the Temple station. Emergence, seedling infection from angular leaf spot, and seed-cotton yields are shown in Table 3. With the exception of the copper-lime dust on the Stoneville 2B seed, all of these treatments gave some increase in seedling emergence. The calomel treatment and the iodine ground in kaolin were somewhat more effective than other treatments in increasing emergence for the Stoneville 2B variety, whereas the Cuprocide plus 5 percent Ceresan was the most effective treatment in this case for the Deltapine 12 variety.

In keeping with results obtained in past years with seed grown in the Southeastern part of the United States, it was found that there was little or no angular leaf spot infection on these seedlings, regardless of whether the seed were or were not treated. It seems apparent, therefore, that most of the seedling infection caused by the angular leaf spot bacteria is carried on the seed. No infection whatever was found on seedlings in these plots where the seed had been treated with Cyanamid 154-6-B dust.

Table 3. Effects of various seed treatments on emergence, seedling infection, and yield from southeastern-grown seed of Stoneville 2B and Deltapine 12 varieties. (Supplemental test—1940.)

Treatment	Emergence percent		Infection percent		Yield of seed cotton, lbs. per acre	
	Stoneville 2B	Deltapine 12	Stoneville 2B	Deltapine 12	Stoneville 2B	Deltapine 12
No treatment	53.0	49.9	1.5	1.5	589	747
Cuprocide	64.3	57.6	0.7	3.1	968	631
Cuprocide + Iodine	64.5	58.7	0.0	1.3	957	579
Cuprocide + 5% Ceresan	67.7	69.6	0.5	2.2	889	747
U. S. Rubber Co. No. 98	61.9	67.0	1.2	1.7	889	805
U. S. Rubber Co. No. 120	64.3	59.8	0.0	0.6	905	673
Iodine in kaolin	70.9	61.1	1.0	2.5	868	926
Sanoseed No. 1—8333	58.9	66.5	2.4	1.7	805	757
Sanoseed No. 1—11000	61.9	64.0	1.2	4.5	857	579
Copper-lime dust	48.3	58.7	3.5	0.7	810	605
Cyanamid 154—6-B	67.4	64.1	0.0	0.0	884	805
Calomel	71.0	60.9	2.6	0.0	852	799

All of the treatments gave good increases in yield with the Stoneville 2B variety, but these effects on yield were inconsistent for the Deltapine 12 variety. There was practically no root rot in the area occupied by this experiment that might result in variations in yield among the plots.

Effects of Different Rates of Dust Application

In some preliminary greenhouse work, it was found that the rate of application of seed-treatment materials could be varied within fairly wide limits without seriously affecting the effectiveness of the treatment. Consequently, certain materials were used at different amounts per bushel to treat seed for experimental plantings in 1940, 1941, and 1942. Both fuzzy and delinted seed were used in these tests. The results given in Table 4 indicate that 5 percent Ceresan had similar effects at rates between ½ and 1½ ounces per bushel. In 1941, slightly better results were obtained as the rate of application of this material was increased, probably because of the unusually wet season. Seedling infection was effectively controlled regardless of the amount of this dust used. Similar results were obtained with the nonmercury dust, Spergon. Finally, the yields of seed cotton were approximately the same with the comparatively low rates of 5 percent Ceresan and Spergon as with the higher rates.

Table 4. Effect of different rates of application of seed-treatment dusts on emergence, seedling infection, and yield of cotton, variety Rogers' Acala 111.

Type of seed	Treatment material	Rate, oz. per bu.	Emergence percent		Seedling infection, percent		Yield, seed cotton, lbs. per A.	
			1940	1941	1940	1941	1940	1941
Fuzzy	No treatment	0	----	52.5	----	49.6	----	660
Fuzzy	5% Ceresan	¼	----	60.9	----	0	----	865
Fuzzy	5% Ceresan	½	84.0	----	1.7	----	634	----
Fuzzy	5% Ceresan	1	85.9	63.1	4.5	0	666	983
Fuzzy	5% Ceresan	1½	81.3	64.8	3.0	0.6	632	821
Kemgas delinted	5% Ceresan	¼	----	66.8	----	0	----	856
Kemgas delinted	5% Ceresan	1	----	69.9	----	0	----	977
Kemgas delinted	5% Ceresan	1½	----	56.5	----	0	----	858
Acid delinted	5% Ceresan	½	86.5	----	4.8	----	657	----
Acid delinted	5% Ceresan	1	84.2	70.9	2.3	0	684	900
Acid delinted	5% Ceresan	1½	88.6	68.2	5.7	1.8	648	966
Fuzzy	2% Ceresan	1½	82.1	----	2.9	----	612	----
Fuzzy	2% Ceresan	3	85.9	----	2.9	----	616	----
Fuzzy	Sanoseed	1½	69.7	----	8.6	----	585	----
Fuzzy	Sanoseed	3	77.5	----	6.7	----	616	----
Fuzzy	Spergon	1	----	55.0	----	0.7	----	856
Fuzzy	Spergon	1½	----	58.4	----	0	----	821
Fuzzy	Spergon	3	----	56.4	----	0.7	----	847

The Effect of Copper Dust Compounds on Fuzzy and Acid-Delinted Cotton Seed

Greenhouse tests have indicated that copper dusts, especially when used on acid-delinted seed might be equally as effective as the organic mercury or other dusts in increasing emergence and reducing seedling infection. Accordingly a test was made in 1942 with varying rates of Red Cuprocide and Yellow Cuprocide, as compared with 5 percent Ceresan and U. S. Rubber No. 604 protectant on fuzzy and acid-delinted seed. Two different varieties of cotton—Rogers' Acala 111 (1941 seed

Table 5. Percentage emergence, seedling infection, and yield of Rogers' Acala 111 and Stoneville 2B cotton seed treated at different rates with copper and other dusts and planted on Houston black clay (HBC) and Austin clay (AC) soils. 1942.

Treatment	Rate, oz. per bu.	Rogers' Acala 111									Stoneville 2B								
		Emergence			Seedling infection			Yield, seed cotton, lbs. per acre			Emergence			Seedling infection			Yield, seed cotton, lbs. per acre		
		HBC	AC	Av.	HBC	AC	Av.	HBC	AC	Av.	HBC	AC	Av.	HBC	AC	Av.	HBC	AC	Av.
Fuzzy seed:																			
No treatment	0	68.9	68.2	68.6	61.7	60.1	60.9	387	255	321	48.6	53.6	51.1	5.2	0.0	2.6	616	528	572
5% Ceresan	1	74.5	71.1	72.8	7.7	3.3	5.5	484	396	440	74.5	78.6	76.6	2.0	1.3	1.6	682	462	572
U. S. Rubber No. 604	¾	71.8	68.9	70.4	2.8	0.7	1.8	519	286	402	74.8	71.8	73.3	0.0	0.0	0.0	625	475	550
U. S. Rubber No. 604	1½	73.2	72.0	72.6	1.3	1.4	1.4	462	330	396	68.4	65.7	67.0	0.0	1.5	0.8	550	484	517
Red Cuprocide	½	70.9	73.4	72.2	9.7	5.3	7.5	462	308	385	70.5	75.0	72.8	0.6	0.6	0.6	713	493	603
Red Cuprocide	1	74.3	65.2	69.8	7.7	4.8	6.2	475	330	402	70.7	76.6	73.6	2.0	0.0	1.0	607	537	572
Red Cuprocide	1½	74.1	68.9	71.5	3.5	0.7	2.1	506	361	434	72.3	70.7	71.5	3.3	0.7	2.0	616	550	583
Yellow Cuprocide	½	71.4	67.0	69.2	6.0	6.5	6.2	607	286	446	68.9	64.3	66.6	0.8	2.3	1.6	572	550	561
Yellow Cuprocide	1	73.0	69.1	71.0	5.8	6.3	6.0	528	296	462	69.3	66.8	68.0	1.4	2.1	1.8	550	418	484
Yellow Cuprocide	1½	67.0	71.6	69.3	3.0	5.8	4.4	519	405	462	70.9	70.5	70.7	2.1	5.4	3.8	669	475	572
Acid delinted seed:																			
No treatment	0	67.5	66.8	67.2	0.0	1.3	0.6	493	374	434	72.3	68.6	70.4	2.6	1.3	2.0	594	317	456
5% Ceresan	1	75.9	73.9	74.9	0.0	0.7	0.4	550	352	451	73.2	78.2	75.7	0.6	0.0	0.3	682	440	561
U. S. Rubber No. 604	¾	66.6	70.0	68.3	4.1	1.3	2.7	581	352	466	74.3	70.5	72.4	0.0	0.0	0.0	607	374	490
U. S. Rubber No. 604	1½	69.8	69.8	69.8	0.7	0.0	0.4	528	449	488	76.1	79.5	77.8	0.0	0.6	0.3	695	519	607
Red Cuprocide	½	75.9	65.2	70.6	0.0	1.4	0.7	528	352	440	70.5	73.7	73.1	0.7	0.7	0.7	581	361	471
Red Cuprocide	1	73.9	62.7	68.3	2.8	3.0	2.9	537	299	418	72.3	66.8	69.6	5.7	0.0	2.8	739	308	524
Red Cuprocide	1½	71.6	74.3	73.0	0.0	1.9	1.0	572	330	451	79.5	74.5	77.0	1.9	0.0	1.0	581	581	581
Yellow Cuprocide	½	80.0	67.7	73.8	1.9	0.7	1.3	493	317	405	75.2	74.8	75.0	2.0	0.7	1.4	757	484	620
Yellow Cuprocide	1	68.0	68.2	68.1	0.7	0.0	0.4	541	352	446	75.5	70.7	73.1	1.9	0.0	1.0	638	330	484
Yellow Cuprocide	1½	70.7	65.7	68.2	2.1	0.7	1.4	581	431	506	75.7	65.0	70.4	0.0	4.0	2.0	669	484	576

produced at Substation 5) and Stoneville 2B (1941 seed produced in Mississippi)—were used for these tests and planted on two different soils. One soil was a deep phase of Houston Black clay and the other Austin clay (a shallow soil of similar derivation as the Houston series). Results of these tests are shown in Table 5. In general, there was no great difference (regardless of rate of application) between the copper dusts, the Ceresan, and the U. S. Rubber Co. No. 604 dusts in regard to the effects on emergence, angular leaf spot control, and yield. Again the locally-grown Acala variety showed more seedling infection in the untreated checks than the southeastern-grown Stoneville 2B. Yield differences were distinct between the two soil types.

From these data it is apparent that the copper compounds should receive further consideration in experiments designed to improve cotton seedling emergence and control seedling diseases in the more alkaline soils of the Southwest.

Seed Treatment Supplemented with Indolebutyric Acid Treatment

Experiments were conducted in the greenhouse and in field plots in 1939 and 1940 to obtain some idea as to the effect of indolebutyric acid on emergence of cotton seed and to study its effect on young seedlings. This material was used as a dust at three different concentrations (1000, 2000, and 3000 ppm. of dust) in combination with neutral talc, 2 percent Ceresan, and Sanoseed (all used at a rate of 3 ounces per bushel), and in aqueous solution in which delinted seed were soaked. Two tests were made in the greenhouse involving fifteen seed for each treatment and replicated eight times for each treatment in each test. In the field in 1940, the same test was made in small single-row plots 25 feet long.

Delinted seed that were soaked in water for 16 hours, with or without indolebutyric acid, started to germinate within 24 hours, and the seedlings emerged within two or three days. Height measurements were recorded thirty days after planting (about the time the third or fourth leaf was forming) in both greenhouse and field tests.

Results of these tests are shown in Table 6. Data obtained are somewhat conflicting, since there was apparently a better emergence where the indolebutyric acid was mixed with Sanoseed, but there was little or no increase when used with other materials. Apparently there was no stimulation from the indolebutyric acid at the concentrations used, regardless of the dosage or combination with other seed-treatment materials. Similar negative results were obtained also in 1940 when seed treated with 5 percent Ceresan containing 1000, 2000, and 3000 ppm. of indolebutyric acid were planted in addition to the main seed treatment tests reported in Table 1.

Table 6. Effect of indolebutyric acid in combination with seed-treatment materials on seedling emergence and early growth of cotton, variety Rogers' Acala 111.

Treatment		Greenhouse		Field	
Fungicide or diluent	Indolebutyric acid ppm.	Emergence percent	Average height, inches	Emergence percent	Average height, inches
Fuzzy seed:*					
No treatment	0	62.7	5.1	28.0	4.2
2% Ceresan	0	80.7	5.2	69.1	4.1
2% Ceresan	1000	85.3	5.0	72.9	4.2
2% Ceresan	2000	86.7	4.8	67.4	4.2
2% Ceresan	5000	78.7	5.4	59.7	4.2
Talc	0	61.3	5.1	26.3	3.9
Talc	1000	61.3	5.0	28.3	4.4
Talc	2000	56.0	4.6	27.4	3.9
Talc	5000	52.0	5.2	29.4	4.3
Sanoseed	0	50.7	4.8	19.7	4.1
Sanoseed	1000	50.7	5.4	29.7	4.0
Sanoseed	2000	70.0	4.9	26.6	4.3
Sanoseed	5000	68.0	4.9	48.3	4.0
Delinted seed:*					
No additional treatment	0	74.7	5.2	21.7	4.3
Water (only)	0	84.0	4.6	38.3	4.6
Water	60	82.7	4.9	40.3	4.2
Water	20	90.0	5.1	30.6	4.4

*The indolebutyric acid was applied in a dry form (dust) to the fuzzy seed; the delinted seed were soaked for 16 hours in an aqueous solution of the chemical.

Field Performance of Different Fractions of Cotton Seed Separated by Weight

In 1940, cotton seed (Rogers' Acala 111) was separated[4] by a centrifugal machine according to weight into 4 fractions and planted in field plots to obtain data on the different fractions as to emergence, seedling infection, and yield. The results given in Table 7 show that a slightly smaller percentage of the seedlings emerged from the lighter seed. The heaviest fraction gave the highest emergence. A composite sample of the seed (nonseparated) had an emergence of 79.4 percent, which was intermediate between the lightest fraction (76.1 percent emergence) and the heaviest fraction (84.4 percent emergence). These differences, however, were not outstanding. The seed were apparently in good condition since the percentage emergence was high even with the fuzzy nontreated seed, and there was comparatively little seedling infection in any of the plots. As for the seed cotton yields, the data showed better yields from the heavier seed-fractions than from the light fractions or from the nontreated composite sample. The fuzzy seed that were treated with 5 percent Ceresan gave the highest yield of seed cotton per acre. This test for one year and with a single seed lot indicates no particular advantage in this type of seed separation.

[4]The seed was separated into the different fractions by the Sutton, Steele & Steele Company, Dallas, Texas.

Table 7. Performance of different fractions of delinted cotton seed separated by weight in comparison with nonseparated delinted, and fuzzy seed.

Treatment	Percent of sample	Weight per bu. lbs.	Emergence per-cent	Seedling leafspot infection percent	Yield seed cotton, pounds per acre
Nonseparated	100	41	79.4	6.2	642
Fraction No. 1 (heavy)	18	43	84.4	6.8	815
Fraction No. 2	32	42	83.0	4.6	821
Fraction No. 3	21	41	81.3	4.6	794
Fraction No. 4 (light)*	27	39	76.1	4.7	710
Nonseparated, fuzzy	100	32	84.8	4.3	778
Nonseparated, fuzzy + 5% Ceresan (1½ oz. per bu.)	100	32	91.5	3.1	899

*A fifth fraction including trash was discarded.

Comparison of Delinting Methods

Field tests were carried out in 1940 and 1941 to compare seed delinted by the ordinary sulphuric acid method, with those delinted commercially under the Brown-Streets patent, with seed delinted by the Kemgas method, and with machine-delinted seed (reginned either in a small cotton gin or at an oil mill). In some cases the delinted seed were further treated with 5 percent Ceresan at a rate of 1½ ounces per bushel. The results of these experiments are shown in Table 8. In 1940 and 1941, the machine-delinted plus Ceresan-treated seed had a somewhat higher emergence than seed delinted or treated by other methods. However, seed that were delinted by the ordinary sulphuric acid method or fuzzy seed treated with 5 percent Ceresan also had a comparatively high emergence. Treatment of delinted seed with Ceresan improved emergence to a certain extent in all cases. In 1941 (exceptionally wet season) all seed that were delinted with acid showed lower emergence than machine-delinted seed, delinted seed plus Ceresan, or nontreated fuzzy seed. Even the fuzzy seed showed a higher emergence of seedlings than certain of the acid-delinting treatments. Seedlings from nontreated seed in 1940 were not infected with angular leaf spot to the degree that is ordinarily obtained. In 1941, there was a high seedling infection on all plots except those planted with acid-delinted or otherwise chemically treated seed. As to yields in 1940, treating with Ceresan, whether on fuzzy or delinted seed, increased yields favorably, and machine delinting gave better yields than acid delinting. In 1941, the yields were somewhat conflicting, however, with delinting alone, all methods except sulphuric acid were better than no treatment; machine

and Kemgas method were best. When Ceresan supplemented delinting, the sulphuric acid process resulted in the best yield.

Table 8. Methods of delinting cotton seed (variety Rogers' Acala 111) as affecting emergence, angular leaf spot infection, and yield.

Method of delinting	treatment	Emergence percent		Seedling infection, percent		Yield, seed cotton, lbs. per acre	
		1940	1941	1940	1941	1940	1941
None	None	57.6	52.3	29.3	89.3	578	748
None	5% Ceresan	72.5	62.7	4.8	3.1	720	645
Sulphuric acid	None	71.3	52.5	7.7	0.0	581	691
Sulphuric acid	5% Ceresan	72.9	55.4	5.9	1.0	700	1003
Corneli* (floaters)	None	---	37.2	---	2.5	---	858
Corneli (floaters)	5% Ceresan	---	39.1	---	2.0	---	898
Corneli (sinkers)	None	---	34.4	---	0.5	---	796
Corneli (sinkers)	5% Ceresan	---	55.1	---	3.6	---	924
Kemgas†	None	---	53.7	---	1.1	---	922
Kemgas	5% Ceresan	---	62.2	---	1.9	---	528
Machine	None	66.5	54.8	5.1	86.2	630	970
Machine	5% Ceresan	77.0	72.8	5.1	3.3	752	763

*Corneli process utilizes concentrated sulphuric acid and separates the light seed (floaters) from the heavy seed (sinkers) by water flotation (Brown-Streets patent).
†In the Kemgas process fumes from heated mixtures of hydrochloric and sulphuric acids are used to remove lint from the seed.

Effect of Varying the Planting Rate of Cotton Seed Treated With Different Materials

Under ordinary farming practices, if sufficient numbers of cotton seedlings emerge to give a good stand of healthy plants after thinning, there should be only minor differences due to seed treatment in the final yield. In most of the early experiments, seed were planted at the rate of ten per hill (five per hill in certain instances). Later, an experiment was planned to determine what effect a difference in rate of planting seed would have on the emergence and angular leaf spot infection of seedlings and on the yield of cotton. In these experiments, seed were planted in hills 18 inches apart at the rate of 2, 5, and 10 seeds per hill. Seedlings were thinned approximately thirty days after planting, to a common stand of not more than 2 per hill. The data from these tests are given in Table 9. Here, it may be seen that seedling emergence was approximately the same for the different treatments at each of the three rates of planting for each year throughout the period of the test. Likewise, there was comparatively little difference in seedling infection among the various treatments. In 1939, the angular leaf spot infection on seedlings from nontreated seed planted at the medium 5-seed-per-hill rate was higher than on seedlings in plots planted at either the 2-seed or 10-seed rates. Otherwise, there was not much difference in infection.

As far as yield of seed cotton is concerned, however, there was in general a greater difference in yield between nontreated and treated seed in the 2-seed-per-hill plantings than at the other two rates of planting. In the plots planted with 5 seed per hill and 10 seed per hill, however, seed treatments also gave higher yields than did plots planted

Table 9. Effects of variation in number of seeds planted per hill, with different seed treatments, on emergence and angular leaf spot infection of seedlings, and yield of cotton (variety Rogers' Acala 111).

Treatment	Emergence percent				Seedling infection percent				Yield, seed cotton, lbs. per acre			
	1939	1940	1941	Ave. diff.*	1939	1940	1941	Ave. diff.*	1939	1940	1941	Ave. diff.*
2 Seeds per hill												
No treatment (check)	40.1	52.2	56.6	----	56.7	31.2	51.3	----	473	493	823	---
2% Ceresan	76.6	67.2	----	25.7	4.8	2.6	----	-40.3	935	585	---	277
5% Ceresan	73.6	76.8	70.1	23.9	7.0	5.9	8.3	-39.3	946	594	823	192
Sanoseed	57.0	56.9	----	10.8	3.7	12.2	----	-36.0	759	578	---	185
Acid delinted	74.7	69.5	68.4	21.3	1.2	4.4	3.1	-43.5	946	675	924	252
Acid delinted + 2% Ceresan	71.9	65.6	----	22.6	6.0	3.6	----	-36.7	935	585	---	277
Acid delinted + 5% Ceresan	72.7	73.4	72.3	23.2	3.7	10.2	1.7	-41.2	1067	666	1025	323
Kemgas delinted	----	----	65.1	8.5	----	----	1.7	-49.6	----	----	959	136
Kemgas delinted + 5% Ceresan	----	----	74.2	17.6	----	----	0.8	-50.5	----	----	1179	356
5 Seeds per hill												
No treatment (check)	39.5	57.6	60.5	----	72.7	29.3	62.0	----	440	578	970	---
2% Ceresan	74.5	78.5	----	27.9	3.1	4.1	----	-47.4	836	740	---	279
5% Ceresan	74.0	72.5	72.0	20.3	4.4	4.8	1.5	-51.1	814	720	961	169
Sanoseed	55.5	55.4	----	6.8	2.2	5.0	----	-47.4	759	595	---	167
Acid delinted	74.8	71.3	69.3	19.3	4.3	7.7	0	-48.7	924	581	968	161
Kemgas delinted	----	----	68.5	8.0	----	----	0.4	-61.6	---	---	1001	31
Kemgas delinted + 5% Ceresan	----	----	72.1	11.6	----	----	1.1	-60.9	---	---	1019	49
10 Seeds per hill												
No treatment (check)	33.4	56.2	58.0	----	52.6	31.9	69.4	----	605	522	986	---
2% Ceresan	69.7	73.7	----	26.9	4.0	2.5	----	-39.0	743	675	---	148
5% Ceresan	71.3	67.9	72.3	21.5	4.4	3.4	0	-43.7	759	605	1245	166
Sanoseed	49.5	56.2	----	8.0	1.3	2.3	----	-40.2	759	524	---	78
Acid delinted	66.8	64.2	73.0	18.8	1.7	8.7	10.1	-44.5	759	641	902	65
Acid delinted + 2% Ceresan	74.0	64.8	----	24.6	1.5	9.1	----	-36.9	759	695	---	163
Acid delinted + 5% Ceresan	76.7	72.3	79.5	27.0	2.1	6.9	2.2	-47.6	715	630	972	68
Kemgas delinted	----	----	65.3	7.3	----	----	1.0	-68.4	---	---	1056	70
Kemgas delinted + 5% Ceresan	----	----	73.7	15.7	----	----	6.9	-62.5	---	---	1087	101

*Average difference is a comparison with checks for the same years. The minus sign designates a number smaller than the checks.

with seed receiving no treatment, with the exception of a few cases in 1941.

Larger, field-scale plantings seem also to bear out this marked difference in yield from nontreated as compared with treated seed at low rates of planting. In some additional tests made in 1940 and 1941, rates of planting were found again to affect the yields materially. Losses due to cotton root-rot disease were found to be lower as the rate of planting was decreased (12). It appears from this work that savings may be effected by seed treatment, at least under certain conditions, in the quantity of seed required to plant a given acreage, provided soil conditions will permit thinner planting of cotton seed.

Summary

This bulletin gives the results of seed-treatment studies with cotton at the Blackland Experiment Station, Temple, Texas, from 1938 to 1942 inclusive, with some data for 1932. Angular leaf spot and sore shin were found to be serious seedling diseases of cotton under blackland conditions. Control of these diseases was attained in varying degrees by the seed treatments tested. In the six years, the emergence of seedlings was increased by seed treatment in about 75 percent of the trials. Likewise, in control of angular leaf spot, the treatments were effective in almost all instances. The yield of seed cotton showed an increase in about 75 percent of the trials, a decrease in 15 percent, and were without effect in about 10 percent of the cases involving seed treatment.

Averages for certain tests show that treatment of fuzzy cotton seed with 2 percent or 5 percent (New Improved) Ceresan increased the stand of seedlings around 25 or 30 percent as compared with nontreated seed. Angular leaf spot infection of Texas-grown seed was only about one-third to one-tenth as severe following these treatments. The yields of lint cotton were from 30 to 130 pounds per acre greater than in the non-treated-seed plots.

In some seasons acid-delinting gave equally as good results as mercurial dusts on fuzzy seed; the highest yields were frequently obtained by use of delinted seed plus a fungicidal dust treatment. All of the chemicals except one (Spergonex) gave marked reduction in seedling infection and, except from machine delinting (reginning) in 1941, all methods of delinting gave good control of seedling infection. No particular fungicide was consistently superior to another. The most satisfactory materials were Ceresan (both 2% and New Improved 5%), Cuprocide, Cyanamid 154-6-B, and Spergon.

Fungicidal dusts containing insoluble copper compounds appeared to be a promising treatment for cotton seed planted in alkaline blackland soil.

Texas-grown seed was found usually to carry more angular leaf spot infection than seed raised in the Southeast. The extent of seedling infection with angular leaf spot never exceeded 5.2 percent for southeastern-grown seed, but amounted to as much as 92 percent with Texas-grown seed. Seed treatments were, therefore, most beneficial when locally grown seed was used.

In the case of certain organic mercury dusts, it was found that the rate of application could be reduced one-half or more below the recommended amounts with about as good results in increasing emergence, in control of angular leaf spot on the seedlings, and in improvement of seed-cotton yield.

No improvement in emergence of seedlings nor in seedling growth was obtained by supplementing the fungicidal dust treatment of the seed with indolebutyric acid.

Separation of the seed according to specific gravity showed no consistent differences in stand or yield between the different fractions of light and heavy seed.

No consistent differences were found between seed lots delinted by different chemical processes.

Greater improvement in yield of seed cotton was derived from seed treatment when only 2 seeds were planted per hill as compared with 5 or 10 seeds per hill (all stands finally thinned to not more than 2 plants per hill, 18 inches apart.) Thus the possibility of using less seed is indicated when properly-treated seed is planted.

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